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THE PROCESS - (INTERNATIONAL) SAFEGUARDS INTERFACE AT THE PORTSMOUTH GCEP FROM THE SAFEGUARDS TECHNOLOGY DEVELOPER'S VIEWPOINT*

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ABSTRACT

The design of a major portion of a safeguards system for possible use by the International Atomic Energy Agency (IAEA) at the Portsmouth Gas Centrifuge Enrichment Plant is described from the viewpoint of the safeguards technology developer. The process-safeguards interface is reviewed, including safeguards, process, and operational constraints on the safeguards system. The conflicting requirements of the IAEA and the plant operator are minimized through the use of advanced technology that allows safeguards data to be acquired, analyzed, and reported in an automated, unattended mode. The proposed safeguards system will reduce the impact of the inspections on both the operator and the IAEA.

INTRODUCTION

Safeguards inspections carried out by the International Atomic Energy Agency (IAEA) are a key element of international efforts to prevent the proliferation of nuclear weapons. Among the nuclear facilities that the IAEA inspects, spent fuel reprocessing plants and uranium enrichment plants are of particular concern because they can change the strategic value of the nuclear materials that they process. The relative ease with which plutonium can be separated from spent reactor fuel has focused safeguards attention on reprocessing plants; however, national desires to be assured of supplies of reactor fuel have led a number of countries to consider purchasing or developing their own uranium enrichment capability with the result that IAEA inspectors are now faced with inspection of a number of enrichment plants. The majority of the facilities that have been built in recent years have employed the gas centrifuge process, which uses relatively little electrical power and allows for plant expansion as demand for enriched uranium grows.

Centrifuge plants present two major problems for international inspection; first, most nations consider the technology to be proprietary or classified and therefore want to limit inspector access to the facilities, and second, the plants can produce nuclear weapons-grade high-enriched uranium (HEU) in short time periods. In addition, the plant operator wants to minimize the disruption caused by inspection activities. Thus, the plant operator would like to keep inspector presence to a minimum, whereas the inspectorate needs to maintain a continuity of knowledge about the operations of the plant. Furthermore, limited inspectorate personnel resources complicate the problem of making credible inspections of large centrifuge facilities.

Safeguards systems designers and technology developers seek solutions to the conflicting requirements of the process operator and the international inspector that maximize safeguards effectiveness and operator acceptability while minimizing the cost and the impact of inspections on the process. The interface between the operator and the inspector is particularly sensitive for international safeguards, and technical solutions to the natural conflicts that occur at the interface are of value to both sides. This paper provides a safeguards technology developer's view of an international safeguards approach for the Portsmouth Gas Centrifuge Enrichment Plant (GCEP) that includes an automated data acquisition, analysis, and reporting system that will permit a significant fraction of the safeguards data to be acquired in a continuous, unattended mode. The complete spectrum of possible IAEA activities at GCEP will not be reviewed here. The process, operational, and safeguards constraints on the design of the system are described, and safeguards technology design solutions are presented.

THE PROCESS - SAFEGUARDS SYSTEM INTERFACE

The first phase of the Portsmouth GCEP consists of two process buildings that will house centrifuge cascades with a separative capacity

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of 2.2 million SWU/yr (separative work units), a feed and withdrawal building, and a recycle/assembly building. In July 1983 the United States Government formally offered the GCEP for IAEA inspection with the expectation that inspections would be carried out in the process buildings and the feed and withdrawal operations in a manner that was consistent with the conclusions of the Hexapartite Safeguards Project,[1] which said that limited cascade access would be allowed to detect possible facility misuse and that materials balance verification efforts would be consistent with IAEA safeguards goals for low-enriched uranium. Exact details of the inspection activities will depend on the outcome of negotiations between the US and the IAEA; however, it is anticipated that the inspections will consist of materials balance verification, cascade building access to verify declared operation of the plant, and reporting by the IAEA of safeguards conclusions.

The proposed safeguards system that is described here was designed by a multi-organization team consisting of the Department of Energy, Union Carbide Corporation--Nuclear Division, Goodyear Atomic Corporation, Brookhaven National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories, with Union Carbide acting as the lead organization. Fluor Engineers, Inc., Irvine, California, is the architect/engineer for the safeguards system facility.

Safeguards Constraints

Effective safeguards for a large, high-throughput plant such as the GCEP could have a serious impact on IAEA resources. Materials balance verification activities by the inspectors must include verification of the ^{235}U weight fraction and the uranium mass of a significant fraction of the feed, product, and tails streams of the enrichment plant.[2,3] Obtaining samples for ^{235}U weight fraction verification by drawing small amounts of UF_6 from cylinders is time-consuming and requires considerable operator cooperation and manpower to handle the cylinders and perform the sampling. Inspection of the cascade buildings to verify that the plant is being operated for the production of the declared low enrichments and to deter HEU production will also be manpower intensive, thus limiting the resources that can be applied to materials balance verification. Unannounced inspections that are carried out with limited frequency can reduce the inspectorate personnel requirements (with the added benefit to the operator of reducing the inspection impact); however, the visits cannot be so infrequent as to reduce the overall effectiveness of the safeguards system. This is particularly true for centrifuge plants, which can be converted to HEU production in a short time. In addition, it is desirable for the IAEA to draw its safeguards conclusions in a timely fashion after inspections have been performed, which adds to the manpower requirements. Inspection data employed by the IAEA must also be obtained independently of the facility operator. These considerations, as well as concern for the impact of inspection activities on the operations of the plant, have led the safeguards technology development community to propose systems for sampling the major streams at the GCEP that are automated and can operate in an unattended mode, including the acquisition, storage, analysis, and reporting of data. Instruments to determine the enrichment of ^{235}U in flowing streams of liquid or gaseous UF_6 have been under development for some time;[4-6] the question before the designers is how to interface these to the GCEP process in a manner that is acceptable to both the IAEA and the operator. It is worth noting that similar automated methods for determining the mass flows have not been developed at this time. The combination of automated, unattended enrichment and mass flow information would allow the IAEA to perform some level (depending on the accuracies of the methods) of materials balance verification without being present at the facility.

Process and Operational Constraints

The GCEP plant operates continuously and employs sensitive equipment that handles UF_6 in forms ranging from low pressure gas to high temperature liquid. IAEA instruments designed to measure the enrichment in the feed, product, and tails streams must be capable of performing the required assay on the physical form of the material, must operate reliably, must provide data that are free from operator tampering, and, above all, must not disrupt the process or put the plant at risk. The GCEP facility has been designed so that it can be expanded beyond its present two process building configuration, thus the inspection system must be able to accommodate the future growth of the facility.

Two locations were considered for IAEA enrichment monitors at the GCEP: the interconnecting process pipeway (IPP), which carries gas between the process buildings and the feed and withdrawal (F/W) building, and in the F/W building near the cylinder connection points. At either location the enrichment monitors would have to be physically attached to GCEP process equipment. A detailed analysis of the flows of the product withdrawal streams in the F/W building at the proposed monitor locations showed that the UF_6 would never achieve the single-phase flow (either gas or liquid) required to employ the developed enrichment monitor technology. In addition, the plant operator desired to keep the IAEA presence in the F/W building (for activities such as instrument calibration and maintenance) to a minimum. As a result of these constraints, the design team concluded that enrichment monitors would be installed in a small inspectorate facility located outside of the F/W building and would sample the gas flows in the IPP system using gas-phase enrichment monitor technology. The decision to locate the monitors near the IPP in a separate building will benefit the IAEA by providing them with a benign environment for their instruments and a location for data analysis equipment and work space. The operator will benefit by confining the inspector's activities to a few areas of the GCEP site.

THE SAFEGUARDS SYSTEM

Although some of the conflicting requirements of the IAEA and the operator are addressed by the use of the enrichment monitors, operating the monitors in a stand alone mode does not solve all of the interface problems. To obtain the maximum benefit from the monitors, they must be incorporated into a system that allows the raw enrichment data to be acquired in an unattended, automated fashion for later analysis by an inspector. In addition, the safeguards system must accommodate the requirements of the limited-frequency, unannounced access (LFUA) inspection strategy to be employed in the process (cascade) buildings to detect possible misoperation of the plant, and it should facilitate the acquisition of other data by the inspectors. Thus the international safeguards system at GCEP can be divided into three major hardware components: the in-line enrichment monitors, the equipment employed for cascade access inspections, and the computer-based data acquisition, analysis, and control system. The LFUA strategy and other inspection activities will not be discussed here as their impacts on the design of the other components of the system are minimal and the interfaces with the process are technically straightforward.

The Enrichment Monitor Subsystem

The IPP system that the enrichment monitors sample contains four main process gas pipes: feed, product, tails, and a spare tails lines. These pipes are large in diameter and handle low pressure gaseous UF_6, making it impractical to consider an in-line installation. Therefore, the monitors were designed to sample the flows on a continuous basis using a slip-stream loop that returns the sample stream to the IPP. The physical interface between the IAEA equipment and the GCEP process is obviously of extreme importance to the success of the safeguards system, and much attention has been given to its design. The design is "transparent," that is, the IAEA inspectors will be able to visually verify the connections and the valve positions between the individual IPP pipes and the monitors. To obtain the highest availability, continuous assay capability, and the highest precision and accuracy, four separate slip-stream loops and enrichment monitors are used. The sampling loops have been designed to protect the main IPP gas handling system in the event of a failure in the enrichment monitors or some other part of the loop. To improve the precision and accuracy of the assays, the gas pressure in the slip-stream loops is boosted using continuous operation pumps. The operator must have control over the slip-stream loop as it connects to the process, but the IAEA must be assured that the loop is, in fact, sampling the major flows in the IPP. In addition to the transparency of the loop design, the enrichment monitors will employ a simple binary flow meter to indicate a no-flow condition.

The high resolution gamma-ray detectors used in the monitors (for details see "Development of an Enrichment Monitor for the Portsmouth GCEP," R. B. Strittmatter et al., in these proceedings) require periodic liquid nitrogen service. To fulfill the requirements for automatic, unattended operation of the safeguards system, an automatic nitrogen fill system was designed. The operator will monitor the operation of the system and will be able to intervene in the event of a failure of the system; however, under normal conditions his only responsibility will be to fill a large exterior storage vessel.

The enrichment monitors are microprocessor-controlled and automatically acquire data and derive an enrichment value from the spectral information based on a calibration stored in the instrument. Measurement control and instrument self diagnostics are also performed automatically. Taps on the slip stream loop provide the IAEA with the opportunity to introduce or withdraw samples for independent calibration of the instrument.

The Computer Subsystem

The data from the enrichment monitors are transmitted to a data concentrating and control computer developed by Sandia National Laboratories called the Enrichment Monitor Processor (EMP). Its function is to communicate with the monitors, provide intermediate storage of the data, interface with the operator's control room in the F/W building, and transmit the monitor data to the inspector's main computer, the IDAS (Inspector's Data Acquisition System). These computers and the associated software are designed to be reliable, easy to maintain, and operate with no operator or inspector intervention. The interfaces with the process are minimal; however, the operator has an interest in knowing the enrichment values obtained by the monitors so that any problems can be detected in a timely fashion. In addition, the operator may use the feed monitor information to detect improper feed enrichments. The EMP will transmit enrichment data, and any alarms generated by the monitors or by diagnostic software in the EMP or IDAS, to the F/W control room. The IDAS computer will receive data from the EMP and the LFUA inspection strategy, store it in a data base, and perform analyses and prepare reports for the inspectors. It will also receive data from the operator's nuclear materials information system for use by the inspector. Figure 1 shows the logical connections between the components of the computer subsystem. Routine maintenance of the computer systems will be performed by the operator or contractor personnel under the observation of both the IAEA and the operator. The details of the computer system are presented in "Computer Safeguards System for the IAEA Inspectors at GCEP," A. L. Baker et al., in these proceedings.

The Inspectorate Facility

The enrichment monitors, the associated slip-stream plumbing, the liquid nitrogen fill system, and the computer systems require a facility to house them that will meet the differing requirements of each of the components. The facility must also provide for the separation of those parts of the system that are under operator control and maintenance from the IAEA equipment that must be tamper-protected. The inspectorate facility, to be located adjacent to the IPP, near the F/W building, is designed to meet these conflicting requirements. Figure 2 is a simplified plan view of the building. The facility is divided into four areas: an operator's pump area that will house the valves, control sensors and pumps for the slip-stream

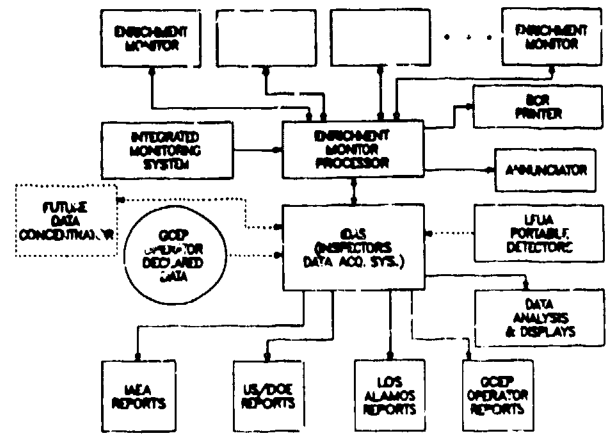

Fig. 1. Logic diagram for the GCEP international safeguards system computer network. Fixed data paths are indicated by solid lines.

loop; an operator's equipment room housing utility equipment; a monitor room; and a room for the computers and inspector's desks. The monitor room and computer room will be sealed and employ intrusion monitoring equipment designed by Sandia National Laboratories. The inspector will be able to examine the operator's pump and equipment rooms and valve seals under escort. The liquid nitrogen fill system is an integral part of the inspectorate facility. The building will also provide storage for the inspection equipment employed in the LFUA strategy. When the inspectors are on site, the facility will be their "headquarters" where they can obtain and work with the data acquired by the monitoring system during their absence and from which they can conduct their other inspection activities. The inspectorate facility provides the instruments and the computers with a benign, tamper-indicating environment that is essential for the reliable operation of the safeguards system, and localizes the inspector's activities, which reduces the operator's security requirements by limiting the inspector movements at the GCEP plant site.

CONCLUSIONS

The international safeguards system that has been designed for the Portsmouth GCEP solves many of the problems associated with the inspection of a sensitive, high throughput, centrifuge

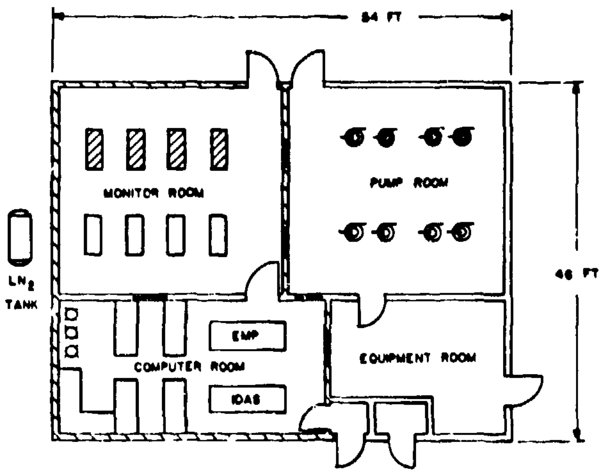

Fig. 2. Plan view of the inspectorate facility for the international safeguards system at the Portsmouth GCEP. The monitor room and the computer room will be sealed and monitored to detect possible penetrations during the inspector's absence.

enrichment plant. It allows for effective safeguards and minimizes the impact of the inspection on both the plant operator and the IAEA. The use of advanced safeguards technology to provide automatic, unattended international safeguards may not be appropriate for small enrichment plants; however, for a GCEP-size facility, the benefits outweigh the costs of the system, and furthermore, the costs are a small fraction of the plant construction and operating costs. The GCEP safeguards system is flexible and can accommodate future expansion of the plant or new safeguards technology such as automated mass flow determination and continuous remote monitoring. Finding solutions to the safeguards problems encountered at the process-safeguards interface at the GCEP has provided valuable experience for safeguards technology developers that will be useful in solving similar problems associated with the international inspection of other large bulk handling facilities.

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